DEFENSE SCIENCE AND TECHNOLOGY STRATEGY

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Defense Science and Technology Strategy

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Department of Defense
Director, Defense Research and Engineering

PREFACE

During the Cold War, the United States faced a single overarching threat that dominated every aspect of military force planning and strategic thinking. During this era we relied upon technologically superior systems to offset the Soviet Bloc's numerically larger forces. Today, this single overarching threat has been replaced by new dangers, such as the proliferation of weapons of mass destruction, regional conflict, and ethnic violence.

Our strategy for managing these post-Cold War dangers to our security rests on three basic lines of defense. The first line of defense is to prevent threats from emerging; the second is to deter threats that do emerge; and the third, if prevention and deterrence fail, is to defeat the threat to our security by using military force. Executing this strategy requires us to maintain strong, ready military forces equipped with a well-integrated, flexible mix of the most advanced technologies.

With today's smaller force structure, readiness and modernization become even more critical to our overall military capabilities. However, we do not seek mere technological superiority. Instead, we seek a force that is capable of dominating any potential foe across the full spectrum of military operations -- dominance allows us to win quickly, decisively and with minimal casualties. We saw this kind of dominance in action during Desert Storm, using stealth, smart weapons and advanced sensors -- technologies developed primarily during the Cold War.

In future conflicts, information technologies will play a critical role in achieving the dominance we seek. That presents several challenges. We must develop the communications, sensors and computing systems to capture, synthesize and distribute near-real time information to all levels of operations. We need to build military applications that extend the capability of our operators and support organizations. And, we must discover and develop whole new concepts through basic research and cultivation of the nation's best scientific and engineering talent.

The challenge for the Department's science and technology program is to put the best available technology into the hands of the customer -- the warfighter -- in a way that is timely and cost effective both tomorrow and far into the future. Doing this requires close, continuous and effective interaction between our warfighters and our technology managers. It also requires maintaining a world-class base of people and facilities. We have such a base today. I am committed to maintaining it into the future. Our Science and Technology program will keep our warfighters at the cutting edge of new technology and ensure our dominance on future battlefields.

William J. Perry

William J. Perry
Secretary of Defense

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I. VISION

Develop and transition superior technology to enable affordable, decisive military capability.

Technological superiority is a principal characteristic of our military advantage. It is the objective of the Department of Defense (DoD) Science and Technology (S&T) Program to develop options for future decisive military capabilities based on superior technology.

Dramatic changes affect our national security. In the next century the United States will face missions and adversaries that are unknown today, proliferation of sophisticated weapons, and the emergence of new kinds of warfare and operations other than war (OOTW) by nations and terrorist elements. Our armed forces will be smaller and field fewer weapon systems than at present.

The next century will also see the results of our current consolidation, diversification, and right-sizing of the defense industry. For an increasing number of technologies, commercial demand, not defense demand, will drive technical progress. DoD can both benefit from and contribute to a stronger US industrial base by aligning defense technology development to complement commercial investment where appropriate. At the same time, we must continue to identify and support a well-defined set of defense-unique, defense-funded capabilities.

"We are not the only nation with competence in defense science and technology. To sustain the lead which brought us victory during Desert Storm...recognizing that over time other nations will develop comparable capabilities, we must...invest in the next generation of defense technologies."

- William J. Perry

The Defense Science and Technology Strategy is responsive to new threats, challenges, demands, and opportunities. Technological superiority remains essential, but is no longer sufficient. Superior weapon system performance must be made more affordable. This demands that the DoD pursue technology in new ways. First, where there is advantage, DoD must use the technology innovations of commercial industry, and realize the cost reductions that come from the economies of scale available in large commercial markets. Second, DoD must develop technologies that reduce the acquisition, operation or maintenance costs of a system.

II. S&T CONTRIBUTIONS TO MILITARY CAPABILITIES

"We must strive to reap the benefits of the ongoing technology explosion, and to gain greater efficiencies in warfighting."

– General John Shalikashvili
Chairman, Joint Chiefs of Staff

Military needs drive DoD's technology investments. It is a fundamental assumption of our national security that the United States' armed forces will be technologically superior to any potential opponent. In the past, technology offset numerically superior forces. Today, technology also enables decisive, rapid victory with minimum casualties and maximum control of collateral damage inflicted. It is imperative that DoD's S&T program invent, develop, and harness technology to realize the new warfighting capabilities required by our military leadership.

The Defense S&T program is guided by the President's National Security Strategy, and the military needs stated by the military Departments, the Joint Chiefs of Staff, and the unified commanders. It reduces the risks to performance and enables more rapid development and deployment of affordable advanced technologies.

The National S&T Strategy

The President's National Science and Technology Strategy presents his comprehensive approach to bringing S&T to the service of our nation's security and global stability. A major emphasis is maintaining military advantage through S&T investment, and a major conclusion is that investments in science and technology are critical to military preparedness.

"The Administration is committed to a sustained investment in the technology base needed to ensure that our nation maintains the best-trained and best-equipped forces in the world. Our investment strategy involves long-term research as well as near-term applications, as it is only in hindsight that we are able to discern the revolutionary military capabilities provided by breakthroughs such as radar, digital computers, semiconductor electronics, lasers, fiber optics, and navigation systems capable of great accuracy."

– Paul Kaminski, Chair, National Science and Technology Council Committee for National Security, and Under Secretary of Defense for Acquisition and Technology

Joint Vision 2010

Joint Vision 2010 is the conceptual template that provides a common direction to help the Military Services develop their unique capabilities within a joint framework of doctrine and programs. This vision of the Chairman of the Joint Chiefs of Staff builds upon the enduring foundation of high quality people and innovative leadership. The traditional concepts of maneuver, strike, protection, and logistics are leveraged with ***technological advances*** and ***information superiority*** to produce improvements which are potentially so powerful that they become, in effect, new operational concepts. These leveraged concepts emerge as:

- **Dominant Maneuver:** The multidimensional application of information and maneuver capabilities to provide coherent operations of air, land, sea, and space forces throughout the breadth, depth, and height of the battlespace to seize the initiative and control the tempo of the operation to a decisive conclusion.

- **Precision Engagement:** The capability to accurately locate the enemy, command and control friendly forces, precisely attack key enemy forces or capabilities, and accurately assess the level of success.

- **Full Dimensional Protection:** The ability to protect our forces at all levels and obtain freedom of action while they deploy, maneuver, and engage an adversary.

- **Focused Logistics:** The capability to respond rapidly to crises, shift warfighting assets between geographic regions, monitor critical resources enroute, and directly deliver tailored logistics at the required level of operations.

These new operational concepts interact to create the powerful, synergistic effect of ***full spectrum dominance,*** the capability to dominate an adversary across the full range of military operations. ***Full spectrum dominance*** emerges as a key characteristic of U.S. Armed Forces for the 21st century.

Full Spectrum Dominance

Full spectrum dominance is heavily dependent upon US forces possessing information superiority. Military advantage accrues from knowing more than the adversary. In this era, information technologies are S&T's silver bullet for the warfighters. Advantage will accrue to the force that assimilates the ongoing world-wide information revolution, and exploits it with advanced warfighting concepts, doctrine, tactics, and procedures.

Comprehensive knowledge of the battlespace, with the ability to see and know more, sooner, and to be able to act decisively in concert upon that knowledge, is a part of all the Joint Warfighting Capability Objectives. The warfighters want specific, accurate knowledge disseminated to the right people in near-real-time over the whole spectrum of defense operations. All our warfighters, from the theater Commander to each individual combatant, must

have the proper information to support their decisions and actions. Information must be timely, and effectively presented for their use.

The technology is at hand. The possibility of delivering almost any information known about a situation almost anywhere at near real-time has sparked discussion of a revolution in military affairs. Because the potential is present, it is the job of the DoD S&T Program to demonstrate the elements of a future global information architecture that would enable revolutionary change, as well as to prototype new applications that challenge today's doctrine and offer new advanced concepts and tactics.

This job requires us both to exploit our nation's current leadership of computer, satellite and communication technology; and to support new concepts in acquisition, assimilation, integration, analysis, management, dissemination and communication of information from all sensors potentially of use in the battlespace. The S&T process must include close and continuous teamwork among DoD planners, technology developers, and warfighters across all military Departments and Defense Agencies. The warfighters require a shared information architecture that enables fully integrated joint warfighting.

There are two challenges to achieving this goal. First, the S&T program must explore how information technology might be harnessed to serve the warfighter. The S&T program includes a rich, diverse set of military demonstrations of applied information technology. Even when entire new technologies are available commercially, it remains a challenge to harness them to serve military applications. For example, communications networks abound commercially, but they do not provide adequate security, defend against information warfare attacks, or assure rapid message delivery. Similarly, there is commercial equipment that provides individuals with mobile communications and computing, but this equipment is not covert where needed, rugged enough to withstand battlefield use, or integrated into a disciplined military command structure. The S&T program's demonstrations allow the warfighters to explore what is possible, formulate advanced concepts, choose options, and develop timely requirements.

The second challenge is to develop the science of information and its handling, to ensure that, in the next several decades, the U. S. continues to lead the world in developing the information technology that can be harnessed to enable warfighting advantage. Technology supremacy is always a race. There is no single solution. Superiority at one time guarantees nothing for the future. Each year or several years, an improvement can be made that can be used to attain a warfighting advantage.

DoD funding of computing and communications science over the past several decades has contributed to both revolutionary breakthroughs and incremental developments. These include the invention of timesharing and the computer mouse, development of graphics, very high performance computers, gigabit communications nets, microelectronics materials and design processes, atomic clocks, speech recognition, and artificial intelligence.

A particularly important part of both these challenges is to manage properly the massive amounts of data produced in a military operation, and to deliver the right information, and only the right information, to the right receivers in a form suited to each receiver's needs. A successful defense information architecture must include many capabilities, including the ability to fuse data from many sources and derive knowledge from the data, ensure its own survival and performance under attack, and disseminate timely information serving all the different tasks that the operating forces require.

The Defense S&T program must continue to press forward, with emphasis in simulation, sensor data fusion, visualization, distributed collaboration, high- speed uncooled electronics materials, single chips that integrate mechanical and electrical devices, intelligent agents that act with user-defined purpose, replacement of electrons with photons, sensors to exploit untapped sections of the electromagnetic spectrum, biomimetics, and light-weight, high-energy batteries. The S&T program must deliver the means for information superiority throughout the battlespace to the warfighter.

Joint Warfighting Capability Objectives

The Joint Staff has articulated twelve high-priority warfighting needs, called Joint Warfighting Capability Objectives. They are not all-inclusive. They are goals that help provide a joint warfighting focus to a significant portion of the Defense S&T program. Although progress can be made on all of them, full mastery of these objectives is in the far future. The objectives will be updated annually as the Joint Requirements Oversight Council reviews and identifies new priorities. The twelve current Joint Warfighting Capability Objectives are:

1. **Information Superiority.** Combines the capabilities of intelligence, surveillance, and reconnaissance (ISR) along with command, control, communications, computers, and intelligence (C4I) to acquire and assimilate information needed to dominate and neutralize adversary forces and effectively employ friendly forces. Includes the capability for near-real-time awareness of the location and activity of friendly, adversary, and neutral forces throughout the battlefield area. Also includes a seamless, robust C4 network linking all friendly forces to provide common awareness of the current situation throughout the battlefield area.

2. **Precision Force.** Capability to destroy selected targets with precision while limiting collateral damage. Includes precision guided munitions, surveillance, targeting, and "sensor-to-shooter" C4I capabilities necessary for responsive, timely force application.

3. **Combat Identification.** Capability to differentiate potential targets as friend, foe, or neutral in sufficient time, with high confidence, and at the requisite range to support weapons release and engagement decisions.

4. **Joint Theater Missile Defense.** Capability to use the assets of multiple Services and Agencies to detect, track, acquire, and destroy enemy theater ballistic missiles and cruise missiles. Includes the seamless flow of information on missile launches by specialized surveillance capabilities, through tracking by sensors from multiple Services and agencies, to missile negation or destruction.

5. **Military Operations in Urban Terrain.** Capability to operate and conduct military operations in built-up areas and to achieve military objectives with minimum casualties and collateral damage. Includes precise weapons, surveillance, navigation, and communications effective in urban areas.

6. **Joint Readiness.** Capability to enhance readiness for joint and combined operations, including capabilities for enhanced simulation for training.

7. **Joint Countermine.** Capability for assured, rapid surveillance, reconnaissance, detection, and neutralization of mines to enable forced entry by expeditionary forces. Included is the capability to control the sea and to conduct amphibious and ground force operational maneuvers against hostile defensive forces employing sea, littoral, and land mines. For land forces, dominance means the ability to conduct in-stride tempo operations in the face of severe land mine threats.

8. **Electronic Warfare.** Capability to disrupt or degrade an enemy's defenses throughout the area and time required to permit the deployment and employment of U.S. and allied combat systems. Includes capabilities to deceive, disrupt, and destroy the surveillance and command and control systems as well as the weapons of an

enemy's integrated air defense network. Also includes capabilities for recognizing attempts by hostile systems to track or engage.

9. **Information Warfare.** Capability to achieve information superiority by affecting an adversary's information, information systems, information-based processes, and computer-based networks while defending one's own information, information-based processes, information-based systems, and computer-based networks.

10. **Chemical/Biological Agent Detection.** Capability for standoff detection of biological agents is our single most pressing need. Capabilities in both point and standoff detection of chemical and biological agents, combined with the ability to assess and disseminate threat information in a timely manner, are critical to protecting fielded forces.

11. **Real-Time Logistics Control.** Capability for near real-time visibility of people, units, equipment, and supplies which are in storage, in process, in transit, or in theater, and the ability to act on this information.

12. **Counterproliferation.** Capability to 1) detect and evaluate the existence of a manufacturing capability for weapons of mass destruction (WMD), and 2) identify and assess the weapon capability of alert and launched WMDs on the battlefield to permit the proper level of counterforce to be exerted promptly. Includes counterforce against hardened WMD storage and production facilities.

III. STRATEGIC INVESTMENT PRIORITIES

Conflicting imperatives drive DoD's S&T program. We must address the joint warfighters' stated needs, maintain a broad-based program spanning all defense-relevant sciences and technologies to anticipate future needs, support the unique needs of the military Departments, preserve long-range research, and do it within limited budgets. At any point in time there are many technologies that are ripe for exploitation and application. These technologies must be explored even when budgets are tight and other opportunities cannot be pursued. Four generic considerations have high priority in making decisions about which specific technologies are pursued.

Affordability

Diminished resources require greater emphasis to be given to affordability throughout the S&T program. DoD acquisitions will not meet the warfighters' needs within current budgets unless we consider reduced costs of development, procurement and life-cycle operation in the S&T program. For the past five years, DoD has dealt with declining budgets by judiciously slowing modernization of our forces to concentrate on maintaining force readiness and quality of life. The result has been our highly successful maintenance of military excellence in the face of deep reductions. But DoD must now embark on a modernization of our forces to ensure continuing readiness in the next century. This modernization will be possible within our reduced budgets when S&T results provide advanced technology that is timely and affordable. Where appropriate, S&T projects must focus on increasing the effectiveness of a capability and decreasing cost, increasing operational life, and incrementally improving material through planned upgrades.

The S&T program provides options to enable modernization of our forces with smaller budgets. Two examples of ongoing DoD S&T projects illustrate S&T's potential. First, Defense Manufacturing Technology projects are providing improved manufacturing processes for reduced fabrication costs and production times, including mature, integrated product and process concepts that permit us to tailor, modify, and optimize the manufacturing process. Second, DoD's programs in artificial intelligence, miniature sensors and materials are enabling development of condition-based maintenance devices that monitor wear, stress and fatigue during operations, and detect and advise of the need for maintenance, thereby improving safety and permitting precise scheduling of maintenance. The result may be dramatically reduced maintenance costs.

Dual Use

Declining procurement resources limit our ability to sustain a defense-unique industrial base, other than in selective areas. Many technologies critical to future warfighting are being developed and matured, commercially and internationally. Therefore, in the future, if DoD is to develop, field and sustain superior materiel, we must rely increasingly on the same industrial base that builds commercial products. There will still be a place for defense industries, both to produce large weapon systems and sustain uniquely defense needs. However, overall, a common commercial and defense industrial base will serve defense needs better, enhance US economic competitiveness, and provide US industry with the benefit of combined, larger markets. The S&T program will contribute to building a common industrial base by utilizing commercial practices, processes, and products, and by developing, where possible, technology that can be the base for both military and commercial products and applications.

Accelerated Transition

To maintain our technological superiority, DoD must field new state-of-the-art systems, within our reduced budgets, at the rapid pace set by the technology revolution. Increasingly, advanced technology is becoming available in international markets,

requiring DoD to accelerate the development process as never before. Rapid technology transition from earliest S&T concepts to the operational forces is crucial.

As a key part of this priority, DoD is taking a portion of the S&T investment for Advanced Concept Technology Demonstrations (ACTDs), assuring that the operator has an opportunity to evaluate selected technologies for an extended duration, in the field, with enough copies to make a military determination of its value. The objectives of this effort are to focus S&T on supporting military needs and problems, speed transitions, and provide a sound basis for acquisition decisions.

A Strong Technology Base

Within the S&T program, the Technology Base is the name given to the basic research, applied research, and education of scientists and engineers that provides the foundation for future military development and applications. The Technology Base generates DoD's legacy to tomorrow's warfighter. The farther into the future we look, the more important technology becomes to the modernization of our forces to ensure military materiel advantage.

It is therefore the objective of the Department of Defense to maintain a stable Technology Base investment, to develop options for the truly long term, beyond the threats, situations and budgets that we can predict. We continue to rely on universities, industry, and DoD laboratories, and on the ability and knowledge of the scientists and engineers in these organizations.

IV. BUILDING THE S&T PROGRAM

Defense S&T planning begins with four overarching sources of information: the guidance of the President's National S&T Strategy and policies of the Secretaries of Defense and the military Departments; the needs identified by the Military Departments, Joint Chiefs of Staff, and Joint Requirements Oversight Council; informal discussions with warfighters to learn their vision of future operations and military needs; and the insights into new technology ideas, opportunities, trends and potential surprises provided by S&T managers and performers.

S&T program plans are built in two ways. First, starting with anticipated operational concepts, the planners deduce what functions might be necessary and how technology might enable attainment of such functional capabilities. Then, the planners devise science and technology projects that explore potential and solve problems along the path toward developing the capability to perform the functions that may be needed. There is a mapping from operational concept, through functions needed to operate in the desired manner, to projects that will deliver the technologies to realize those functions. Second, in contrast, planners also start from an anticipated scientific opportunity, and devise a program to explore that opportunity, although its contribution to military operations is not yet defined.

The guidance, priorities, and principles set out in this Strategy, and in the other guidance documents cited, are used to modulate planning and to make choices within limited budgets. Both DoD corporate priorities and component priorities are observed. The result is a series of annual documents that implement this S&T Strategy. These documents are the Joint Warfighting S&T Plan, Defense Technology Plan, DoD Basic Research Plan, and various plans of the Military Departments and Defense Agencies.

The Joint Warfighting S&T Plan, Defense Technology Area Plan (DTAP), and Basic Research Plan document the overall DoD S&T technology effort. Goals, objectives, schedules, and funding are defined for each of the ten technology areas identified in the DTAP. These plans also discuss opportunities for transitioning technology rapidly into fielded systems, and projected operational payoffs. They are used to ensure that component efforts are responsive to the overall DoD strategy and vision, and that multiple component efforts are complementary. They state some high priority corporate DoD objectives, both to communicate them, and as a basis for review and evaluation.

Science and Technology efforts are inherently unpredictable, so these plans will evolve as new opportunities arise, tasks are discovered to be unachievable, and military needs change. All three plans will be updated as appropriate annually.

Structure of the S&T Program

Congress authorizes and appropriates funds for Defense S&T in three budget categories -- Basic Research (6.1 account), Applied Research (6.2 account), and Advanced Technology Development (6.3 account) -- and requires that DoD fund and justify its S&T efforts within these categories.

The Basic Research Program (6.1) produces knowledge in a science or engineering area. It cannot be known whether a particular scientific result will lead to a military application. While sometimes research pays a dividend with a transition directly from the research laboratory to a defense system in the field, breakthroughs often require decades before the potential is harnessed for military use. Most research products are incremental evolutionary advances; revolutionary breakthroughs are rare, but highly valuable.

Basic research is a long-term investment, with emphasis on opportunities far in the future. The basic research program investments are in twelve areas: atmospheric and space sciences, biological and medical sciences, chemistry, cognitive and neural sciences, computer sciences, electronics, materials science, mathematics, mechanics, ocean sciences, physics, and

terrestrial sciences. Universities perform more than half of DoD's basic research program. Scientists and engineers at DoD laboratories also perform research. A portion of the program is placed in industry, non-profit research institutes, and other federal laboratories. The university research involves graduate students, thus educating young scientists and engineers to be familiar with DoD needs and problems.

The Applied Research (6.2) and Advanced Technology Development (6.3) programs mature technologies for military use. In some cases prototype systems embodying a technology are built. Applied Research provides proof of concept experiments and evaluations built around models and laboratory experiments. Advanced Technology Development begins to harness technological advances to provide military capability.

Moving Technology Rapidly Into Use - ATDs and ACTDs

The DoD S&T program is structured to accelerate movement of technologies through the continuum to maturity through Advanced Technology Demonstrations (ATDs) and Advanced Concept Technology Demonstrations (ACTDs).

ATDs are the military Departments' and Defense Agencies' narrowly focused technology demonstrations, to identify key technologies ready for transition and demonstrate their performance parameters. ACTDs are DoD's broadly-based proof of concept demonstrations, to evaluate the military utility of mature advanced technologies. Jointly planned by users and technology experts, an ACTD enables operational forces to experiment in the field with new technology in order to evaluate potential changes to doctrine, operational concepts, tactics, modernization plans, and training. The field environment provides realism and surrounding context for evaluation. They involve the warfighters in the investigation of new technology concepts while exploration of applications in warfighting systems is still at an informal stage. This allows iterative change of both the system construct and the user's concept of operation without the normal constraints and costs incurred when the rigidity of formal acquisition is involved.

ACTDs are warfighter-oriented, even warfighter-dominated. They have three motivations: l) to have the user gain an understanding and evaluate the military utility of a technology concept before committing to acquisition; 2) to develop corresponding concepts of operation and doctrine that make best use of the new technology; and 3) to provide residual operational capability to the operating forces for in-depth, sustained evaluation. Each ACTD provides the commander with the ability to continue to refine doctrine and tactics to maximize the potential of new technologies.

The outcome of an ATD or ACTD is judged by both the warfighters and S&T planners. If a military Department decides that an ATD's or ACTD's demonstration does not satisfy their needs, an ATD or ACTD terminates consistent with the user's reasons. If, on the other hand, a military Department determines that the demonstrated concept should be brought into the operating forces, there are two possible avenues. First, if large numbers are required, the system will enter the acquisition process at whatever stage good judgment dictates. Second, if only small numbers are required, it may be preferable to modify the demonstration system appropriately and then to replicate it as needed. This latter avenue might apply to command and control, surveillance, and Special Operations equipment, as well as to complex software systems where evolutionary development, with routine upgrades, is preferred.

The Continuum of Technology Exploration

The budget categories divide S&T according to fiscal and accounting criteria. But the S&T program is actually managed and executed across the continuum in which technology advances.

Technology maturation is a richly complex process. Funding is an important driver, but not the only one. A major consequence of the many paths of technology maturation is its unpredictability. New opportunities arise, new approaches fail to produce hoped-for results, and old plans are adapted or abandoned constantly. The DoD Science and Technology program is always being redirected. Uncomfortable as this erratic course is for DoD planners, it is a sign of the program's vitality.

Technologies developed for one defense purpose often transition to many others. For example, DoD conducted the basic research in the mathematics of non-linear phenomena (chaos) that has enabled prediction of irregularly occurring events, with many uses for both the warfighters and greater society. Non-linear mathematics, for example, enables control of the unstable frequencies of blue-green lasers, allowing development of lasers with intensities high enough to penetrate water predictably, and thus serves as a basis for an inexpensive detector of buried mines. Both the Navy and commercial carriers have applied the same non-linear mathematics to program computers for controlling cranes that are moving cargo in a rolling sea. The same mathematics has been used to predict the irregular heartbeat of medical patients with atrial fibrillation, enabling hospitals to prescribe corrective treatment and develop programmable pacemakers. At present, non-linear mathematics discovered for DoD is being applied to predict the irregular occurrence of epileptic seizures, and to scramble microwave signals for both military communications and cellular telephones.

The reverse of these success stories is failure. Many S&T projects do not succeed, although the projects may have showed great promise when begun. S&T planners use every means to ensure funds are wisely allocated to promising projects, including advisory boards, reviews, and international monitoring; but we make no apologies for intelligent false starts. Investigations may yield no useful results, but make sense scientifically, and provide the valuable knowledge of what will not work.

The time required for a scientific idea to mature varies widely. For example, the capability for operations at night, effectively demonstrated in Operation Desert Storm, was enabled by research in infrared imaging begun during the 1950s, followed by development and field testing of the first militarily useful demonstrations in the 1970s, procurement and training for combined arms use in the 1980s, and combat use in the early 1990s. Conversely, NASA and commercial communications firms developed broadcast satellites over a single decade, and DoD was able to adapt them readily to defense communications. A

few S&T results have catapulted directly to operational use, like application of generalized rate scheduling mathematics to aircraft sortie planning, and sterile all-type artificial blood substitute. In another example, after paratroopers collided when test-jumping from a prototype aircraft, use of computer codes from computational fluid dynamics produced a model in three weeks that enabled adjustment of the way the aircraft is flown, so that collisions were avoided without costly aircraft redesign or mission limitations.

V. MANAGEMENT AND OVERSIGHT OF THE S&T PROGRAM

The Director, Defense Research and Engineering (DDR&E) is responsible for the overall direction, quality, and content of the DoD S&T Program. The DDR&E ensures that the program responds to the needs of the warfighters and to the national goals embraced in this S&T Strategy's vision. The Deputy Under Secretary of Defense for Advanced Technology is responsible for creation and oversight of Advanced Concept Technology Demonstrations.

The S&T Program is planned, programmed, and conducted by the military Departments and the Defense Agencies. The Departments use their S&T programs to provide warfighting and system options for their components. The Defense Agencies are responsible for certain multi-Service aspects of S&T, and for designated programs that support national security objectives. The Defense Advanced Research Projects Agency (DARPA) is charged with seeking breakthrough concepts and technology, and with investing in technologies that are heavily dual-use in nature. The Defense Nuclear Agency provides S&T supporting specific nuclear weapons applications, and develops technologies to provide protection against weapon effects. The Ballistic Missile Defense Office has inherited the mission of the Strategic Defense Initiative to seek technologies to deter and defeat strategic attack.

The Departments and Defense Agencies coordinate their programs through Defense S&T Reliance. Reliance provides a forum where S&T programs are planned, balanced and reviewed jointly, to ensure that unnecessary duplication is eliminated and to ensure compliance with this Strategy and Defense Planning Guidance. Reliance is overseen by an Executive Committee chaired by the Deputy Director, Defense Research and Engineering. Reliance has grown in strength over the past years. It is now responsible for preparing the Joint Warfighting S&T Plan, Defense Technology Area Plan, and Basic Research Plan.

Guiding Principles for Science and Technology Management

The Defense Science and Technology program needs to be grounded in a deep understanding of fundamental science, and a broad-based understanding of technology and how it evolves. In this context, options for dramatic new military capabilities can be recognized and exploited, and the U.S. can anticipate and counter unexpected developments in capabilities of potential adversaries.

While technological superiority remains a guiding objective, the new world demands a more balanced approach to technology, product, and process development. Lower budgets drive an increased emphasis on affordability, longer lived weapon systems, and insertion of new technology.

Reduction of costs is an important exit criteria as technology transitions to fielded systems. Health of the defense industrial base also requires increased attention; DoD is supporting commercial-military industrial integration by developing dual use technology, where appropriate. Close connection with the science community outside DoD is crucial to assure scientific progress in military-relevant fields.

All this places new demands on and requires new approaches for the management of S&T resources. Five guiding management principles direct the S&T programs of the military Departments and Defense Agencies. These management principles are designed to place in the hands of our operational forces the best mix of capabilities possible, in the short and long term, by leveraging the best resources in the DoD and the nation:

1. Transition Technology To Address Warfighting Needs
2. Reduce Cost
3. Strengthen the Industrial Base
4. Promote Basic Research
5. Assure Quality

1. Transition Technology to Address Warfighting Needs

Develop and Transition Superior Military Technology

During the Cold War, our former S&T program was challenged to produce weapons that were capable of countering a numerically superior, sophisticated enemy. Technology was driven by a need to counter a capable Army with large armor, artillery, and infantry forces; a formidable Navy, both on and below the surface; and an Air Force that introduced new high performance fighter and strategic aircraft on a frequent, but predictable, cycle.

The potential regional adversaries of today typically lack an indigenous capability to build a variety of arms, and so buy the most sophisticated technology they can afford in the international arms market. Any group with sufficient resources can buy the best available. The challenge for today's S&T program is thus to transition affordable technology to U.S. warfighting capabilities faster than it is supplied to the international market. If the U.S. transitions technology into weapons systems faster than anyone else, then our forces will have the best before it is available to potential adversaries.

Work With The Warfighters. It is the warfighters who must determine what capabilities are needed and therefore what systems will be purchased. When technologies have emerged from the laboratory, technologists work with users to articulate capability needs matched with technology opportunities. That is the basis for defining the new Advanced Concept Technology Demonstrations (ACTDs). ACTDs provide a basis for sound and reasoned acquisition decisions, and better understanding of performance, cost and schedule risks.

Ensure that Joint Needs are Met. Effective operations of all components of a joint force are becoming ever more critical, as information technologies enable closer coupling and more tightly integrated actions and reactions. DoD's S&T program gives high priority to joint needs, and ensures that technologies are being developed to serve specifically joint forces. This principle suggests integration of sensors, weapons, communications, situational displays, and navigation systems across the Services. This year, the Joint Staff and DDR&E have instituted the Joint Warfighting S&T Plan, which ensures that technology programs demonstrate options to address the needs approved by the Joint Requirements Oversight Council.

Insert Promising Concepts into Development Programs Rapidly. The various stages of the DoD S&T program are a continuum. Typically, a new concept arises from research, crystallizes into a technology that can be explored in the laboratory, and lastly becomes a technology that can be transitioned into a military system. There is a premium on moving rapidly through this continuum.

Insert Technology Into In-Service Systems. It is possible to upgrade in-service systems with defense-unique or commercial components or sub-systems that incorporate new technology. Three areas in particular offer opportunities to upgrade in-service systems with new technology. The first is software. Software upgrades can often provide significant enhancements without physical change to the weapon system. For example, software to fuse information from multiple sensors is becoming available, and can be transitioned rapidly. Second is electronics, where U.S. firms have selective, significant international advantage. The third area where in-service upgrades appear particularly applicable is that of self-contained sub-systems, such as aircraft radar's, torpedo propulsors, and armored vehicle fire suppression systems. By putting new technology rapidly into operational systems, the military capabilities of long-lived platforms can be enhanced.

Prevent Technological Surprise. Technological surprise historically occurs when new technology is employed with a surprising concept of operations. The global arms market

transfers new weapon systems to any nation that can pay for them. The U.S. needs to be vigilant to guard against surprise. This requires good intelligence on weapons availability and military concepts of potential adversaries. It also requires that the U.S. S&T community maintain a continuing awareness, through its own scientific investigation, of emerging technology that could have military application. Defense scientists and engineers must understand the potential of emerging technologies and be poised to react rapidly to an innovative use of technology by potential adversaries. ATDs and ACTDs will speed consideration of alternative operational concepts for U.S. employment of new technology.

2. Reduce Cost

Reduce Both Acquisition and Life Cycle Costs.

With the DoD beginning to recapitalize our forces within reduced budgets, the S&T program has adopted cost reduction as an objective equal to performance and new capability. The cost of ownership, operation, maintenance, and evolutionary upgrade is greater than the cost of acquisition for most systems. Thus, full life cycle costs must be considered during technology development and demonstration; consideration cannot wait until product development. Because eighty percent of the life cycle cost of a system is normally determined during the concept and preliminary design phase, affordability must be a key technology and design objective.

The DDR&E has chartered an Affordability Task Force, under the auspices of the Defense Manufacturing Council, which has addressed these issues and developed a set of criteria against which S&T programs can be measured for their attention to affordability. Specific programs have been designated as "Affordability Programs." These will be tracked on an ongoing basis through review and assessment of the Defense Technology Area Plan. Education and training modules will be developed to promote application of integrated process and product development principles to these Affordability Programs. Each military Department has increased the size of its program that is focused on affordability.

Insert Technologies that Reduce the Cost of Ownership. DoD must seek out technology and applications that reduce the cost of operating, maintaining, and upgrading systems, and insert those technologies at every stage of a system's acquisition and life-cycle. New concepts like embedded corrosion and fracture sensors, non-destructive testing techniques, and improvements in the speed and effectiveness of artificially intelligent diagnostic tools must be pursued and incorporated in operating systems.

Use the Best Commercial Products, Practices, and Processes. The Department of Defense must exploit national and international commercial practices, standards, technologies, products, and protocols as the rule, rather than the exception. Scientists and engineers in the S&T program need to be cognizant of this even as they are making tradeoffs in the laboratory. Investments in dual-use technology and products with potential for both defense and commercial applications can encourage commercial companies to reduce the time to reach production, and reap benefit from the economies of scale that derive from commercial, mass markets. Where DoD needs unique items, the objective is to manufacture them on flexible production lines.

Simulate. Modeling and simulation have come of age. They offer promise as tools during the technology development process as well as during the setting of requirements and acquisition. Automated simulation technology provides a richer context than is otherwise possible, allowing technology to be evaluated under a broad set of conditions. Use of simulation allows technologists and warfighters to collaborate earlier in the development process, and provides users the means for a more thorough evaluation of concepts. It can provide improved cost-benefit analyses, better requirements, more comprehensive performance trade-off analyses, more producible designs, and more productive testing. Simulation can result in substantial cost reductions.

Improve Manufacturing Processes. Manufacturing as practiced in the United States is undergoing rapid changes to reduce cost, enhance quality, and add new capability in terms of flexibility and agility. The Department must continue to invest in accelerating this change and capitalizing on it for defense needs. Metrics are not only reduced cost to manufacture and reduced cost for low rate production, but a shorter design and engineering phase, earlier detection and correction of manufacturing difficulties, reduced test and evaluation time, reduced defect per manufacturing lot, and rapidly adaptable manufacturing lines. A broad program is being pursued. Efforts include l) easily reconfigurable manufacturing equipment to allow economical,

variable-volume lot runs; 2) integrated product and process development that permits production analysis during product design and the tailoring of both the product and the process; and 3) cost reduction of the combination of technology and manufacturing.

Consider Environmental Factors. Life cycle costs include environmental costs from pollution prevention during manufacturing to clean-up of bases, depots, and ranges. Environmental law compliance costs and environmental restoration costs are growing rapidly, particularly as the Department of Defense seeks to return closed base property to communities. DoD has an S&T program to develop and harness technologies to reduce the production of pollutants, reduce the cost of environmental clean-up and restoration, destroy munitions and systems in a more environmentally benign way, and isolate environmentally hazardous substances more reliably, at less cost, and for a longer time. The S&T program is developing tools, to be included in life cycle cost models, that will address environmental issues early in the design phase of new systems.

In the past, DoD's environmental technology program had a sharp focus on reducing the costs to clean up contamination. That focused effort produced many technologies which the U.S. has shared with other nations. The focus has shifted recently to avoid future cleanup costs, by emphasizing pollution prevention, and conservation across the whole range of environmental concerns.

3. Strengthen the Industrial Base

Wherever Possible, Use the Same Technology and Industrial Base to Build Military and Commercial Products.

DoD needs the aggressive technology maturation rates and cost reductions that come with mass production. In times past, DoD often developed its own technology, or its own version of non-defense technology, for use in military products. DoD paid the costs to define and sustain a defense industry partially set apart from civilian industry.

Today, that strategy is not practical. In addition, technologies critical to achieving future advances in military capability are increasingly developed by civilian industry -- both inside and outside the United States -- in key sectors such as computers, electronics, advanced materials, and biotechnology. In some areas, national and international research and development investments outside the Department of Defense dominate DoD's investment. DoD must monitor and exploit these advances.

It is an objective of the Defense S&T program to use the same technology and the same industrial base, where feasible, to build military products and commercial products. The goal of the S&T program is to achieve military technological superiority in a fashion that serves both classes of products.

Develop Dual Use Technologies and Processes. Dual use refers to technologies, processes, and products with both military and non-military application. A technology or process may first be developed for a military context and then be applied to commercial use, or vice-versa. Commercial and military application may be pursued in parallel. All paths lead to dual use applications. The S&T program will be managed to nurture both kinds of applications.

It is imperative that DoD foster, to the maximum extent practical, an integration of military and commercial industry in order to achieve a more cost-effective, single set of industrial enterprises that are capable of developing and building more affordable and productive military and commercial products. The Defense S&T investment can be made so as to contribute to this integration by preferentially developing technologies that have dual use, when that is possible. The majority of the S&T investment is already made in dual use technologies and processes. DoD has a long history of sustained investment both in technology development and in industrial process maturation that directly contributed to commercial economic growth and job creation. This has been one of the strengths of the DoD S&T program.

The Dual-Use Applications Program is a new effort which builds on the Technology Reinvestment Project. The Technology Reinvestment Project was a highly successful and fundamentally new approach to the acquisition of technology for DoD, based on entrepreneurial leverage of superior commercial technologies using cost sharing and government-industry partnerships. The Dual Use Applications Program moves beyond its predecessor by embedding this new approach in acquisition programs. The Dual-Use Applications Program is built around a three-year process of transition, designed to root the principles of dual-use throughout DoD. Government-industry partnership projects will be solicited, and selected to meet DoD needs. They will be managed by the military Departments along a clear path for incorporation of new technologies into deployable systems. The program will use innovative contracting procedures, such as Other Transactions and Cooperative Agreements, to provide more creative arrangements between the government and performing consortia than are available under conventional procurement practices.

Sustain Service-Essential Disciplines and Industries. An important caveat to emphasis on joint operations and dual-use is that there will remain technologies and industries that will not be incorporated in joint operations or sustained by commercial markets, but are nevertheless critical to the warfighters. Vital technologies such as thick composite materials, ocean

acoustics, hydrodynamics, and high-density propellants will likely remain uniquely of interest to one or two military Departments, and will never transition enough commercially viable products to sustain development without DoD leadership. The military Departments must bear the cost and the responsibility for advancing these technologies and nurturing the research and development component of those industries.

Sustain Investment In Priority Technologies. Another strength of the S&T program has been its ability to sustain an investment from the birth of a technology until it has matured as the basis for a substantial and stable industry. This must be continued. The DoD investment in electronics provides one example. Since the 1960s DoD has invested in microelectronics. In 1965 DoD purchased more than 50 percent of the semiconductors manufactured in the U.S. Today DoD purchases less than one per cent of a much larger market. Industrial research and development investment in this area now dwarfs that of DoD. However, DoD made crucial early, long-term investments in microelectronics technology and fabrication process maturation that industry, with a shorter term investment horizon, could not make. It continues to do so in selected areas. DoD's investment has paid dividends many times over, not just for the armed forces, but for the country.

Over the past eighteen months, DoD has performed a systematic evaluation of industries to determine where DoD investment is mandatory to ensure continued vitality of essential capabilities. In most cases subsidies are not justified, but in some, longer-term S&T investments are warranted. Current initiatives in technology maturation include multi-chip modules, uncooled infrared focal plane arrays, microelectrical-mechanical systems, lithography, flat panel displays, titanium metal matrix composites, nano-manufacturing, and optical electronics.

The Department of Defense will continue to make sustained S&T investments in the most militarily relevant dual use technologies to the extent that its budget permits. Its own need to exploit a technology guides that investment. Because the DoD is both an investor in science and technology, and also a consumer of the derivative products, it has excellent insight into what

technologies are most promising from a military perspective. Because benefit is not realized by the military until production is achieved, the DoD has both the motivation for a sustained investment and the basis for judgment of whether progress is being made toward achieving acceptable military products.

Exploit Commercial Technologies. There is an increased opportunity to meet defense needs by adopting commercial technology and commercial products, such as electronics, software, and communications. The Services must monitor commercial product offerings and be the catalyst for the adoption of such products where they offer advantages. Incentives must be created to catalyze and facilitate insertion of commercial technology into defense systems.

Strengthen Technology Transfer. The military Departments' programs that foster dual use technology development, ensure exploitation of commercial technology, and nurture technology transfer among in-house laboratories, industry, universities and not-for-profit laboratories will be strengthened. It is expected that there will be an increase in the shared use of facilities by laboratories and industry. Participation in regional, state, and local alliances will be encouraged. A change in laboratory culture is required, and has already started to occur, as evidenced by the increase in laboratory collaborations with industry using Cooperative Research and Development Agreements.

Field Selected Initiatives to Apply Technology to Societal Needs. DoD will identify economic and societal needs where it has special ability to lead in the application of technology. These needs include counter-proliferation, environmental compliance, aviation, energy, infectious disease originating outside the U.S., and information systems. Prototype services and applications will be built. The Defense Advanced Research Projects Agency (DARPA) has fostered many technologies that today provide the opportunity to create the National Information Infrastructure. DARPA will prototype selected high priority information infrastructure applications.

4. Promote Basic Research

Expand Fundamental Scientific Knowledge That May Lead To Future Warfighting Capabilities.

Our nation's defense advantage is grounded in the widest scope of scientific knowledge. Since there is never a requirement for something unknown, DoD invests broadly in all defense-relevant scientific fields. Defense basic research has five objectives: first, to discover new knowledge in fields relevant to warfare; second, to avoid technological surprises; third, to create technological surprises for our adversaries; fourth, to sustain a community of scientists and engineers who exploit new knowledge as they seek new warfighting capabilities; and fifth, to train the next generation of scientists and engineers in areas critical to national security.

By its very nature, basic research potentially applies to both military and non-military needs. Thus, the DoD basic research program supports both economic security and national security. Although DoD provides about eight percent of the whole federal investment in scientific research, it provides a higher percentage of the federal investment in the fields most relevant to its national security interests. DoD is a principal federal supporter of research in electrical engineering, metallurgy and metallic materials, mathematics, mechanical engineering, the computer sciences, and civil engineering. Although this research has wide societal value, warfighting mission imperatives drive DoD's involvement in these fields, and there is no evident replacement for DoD's sponsorship.

Support Quality Basic Research. As new ideas emerge, only those who have a deep, long-lived involvement in clarifying those ideas fully understand them and have an opportunity to recognize their potential application. DoD requires a basic research program to assure that it has early cognizance of new scientific ideas. It is not usually possible to predict precisely what

knowledge will eventually be of value. The Department of Defense sustains its investment in basic research because of proven experience of significant, long term benefits to the military. Research provided the foundation for technological superiority in each of our recent conflicts. Radar made a material contribution to winning World War II. Stealth, lasers, infrared night vision, and electronics for precision strike played a major part in recent warfare. Research will surface the next breakthrough.

Select Research Performers Based on Merit. Because basic research is essentially an exploration of the unknown, it is important that it be conducted by the highest quality people. The DoD involves first-rate scientists found in universities, industry, DoD laboratories, other government laboratories, and the Federally Funded Research and Development Centers. The program is managed to support the best researchers, regardless of organizational location. Merit based selection of projects ensures quality.

Sustain Stable Research Funding. Research typically requires many years to reach fruition. In this time of precipitous budget change, it is incumbent on the science and technology management to ensure stable funding for the highest priority efforts. Disruption of a research project is difficult to reverse. For example, research efforts that revolve around a few individuals typically cannot be restarted if even one or two of the individuals depart. It has been, and is, a priority of this Defense administration to sustain stable funding for basic research.

Educate Future Scientists and Engineers. The nation and DoD require a steady influx of educated scientists and engineers with an interest in and knowledge of defense problems. To ensure that this supply of technical talent will continue, DoD sustains its long-standing commitment to support students studying science and engineering. It will continue the small, but important, programs to bring students to the Defense laboratories on cooperative or other arrangements in order to involve them first-hand in defense problems. To make full use of the potential of U.S. citizens, DoD will continue to strengthen the scientific capability of the colleges and universities with significant student enrollments from minorities underrepresented in science and

engineering. DoD will provide science-related infrastructure, as well as funding for defense research and engineering programs.

Promote Teamwork and Partnerships. The DoD basic research program fosters teamwork and partnerships of many forms: DoD laboratory researchers teaming with in-service material engineers in the laboratories to explore jointly the symptoms of component failure; Defense laboratory scientists teaming with university or industrial scientists, perhaps drawn together to share use of laboratory equipment or instruments; consortia of universities and of universities and industry; and allies. The program seeks to not only value tradition, but to encourage and embrace innovative change.

There is also a mutual dependence between DoD and other government science and technology organizations. Nurturing and leveraging this extended community has taken on increased importance in recent years. DoD relies upon NASA for the development and testing of some space-bound systems, the National Oceanographic and Atmospheric Administration for weather information, and DOE for nuclear weapons. Many programs involve close coordination between DoD and other government agencies.

5. Assure Quality

Assure That Excellent Scientists And Engineers,
Supported By First Rate Facilities,
Continue To Develop Superior Military Technology.

Quality is more important than quantity in the execution of the S&T program. It is more productive to have fewer, but better scientists and engineers, fewer but better facilities, and fewer but better products. This holds true for work performed inside the Defense laboratories, as well as that contracted outside. The DoD's S&T leaders must accept the challenge to take action to assure the quality of our S&T products in the downsizing post-Cold War environment.

As DoD laboratories become smaller, an even greater premium must be placed on ensuring the excellence of the people, the facilities they work in, and the equipment they use. DoD will size its laboratories so that future budgets are adequate to recruit and retain top scientists and engineers, and to maintain and operate modern facilities and equipment. Recent efforts to improve laboratory quality include: improved contracting procedures; more effective control of laboratory facility management; discretionary budgets for laboratory technical directors; stability of technical directors; and improved personnel practices for scientists and engineers. Some progress has been made.

Existing bureaucracy and personnel system rules contribute to several disadvantageous actions. Consequently, part of the laboratory restructuring effort includes attention to legislative changes necessary to permit more effective and efficient laboratory management. Key to this is the recent Office of Personnel Management (OPM) approval to begin a phased implementation of the Laboratory Demonstration (Lab Demo) initiative within the overall Laboratory Quality Improvement Program (LQIP). Lab Demo is a broad successor to the China

Lake Experiment that will allow the various DoD laboratories to more closely manage their civilian workforce on a new contributions based compensation system. The program is expected to begin 1 Oct 96 with direct management of the core Scientists and Engineers (S&Es) and expand over time to encompass all laboratory civilian personnel.

DoD will continue to apply, across the entire S&T community, the best practices for evaluating the stewardship of S&T resources, through the use of peer reviews, benchmarking, and other metrics. DoD scientists must be second to none. Professional education, publications, and other forms of scientific recognition are some metrics of research staff quality. Innovation will continue to be stimulated and rewarded, and risk-taking will be encouraged.

Downsize, Outsource, and Restructure the DoD RDT&E Infrastructure. Budget reductions, particularly those in the procurement and modernization accounts, require reduction of the Research, Development, Test, and Evaluation (RDT&E) infrastructure of which the S&T infrastructure is an integral part. These include the DoD laboratories; research, development and engineering centers; test centers; university centers, federal laboratories, Federally Funded Research and Development Centers; non-profit corporations; and even industry. Reduction of people, facilities, and sites must be made carefully. The infrastructure itself, with its ability to act and react, is an important product of the RDT&E program. Those portions that are critical to our future must be retained, restructured as necessary, strengthened, and sized so as to be supportable with future DoD budgets. DoD must reassess the conditions under which it maintains in-house technological capability. Today, it may be more effective to rely on industry or universities for those technologies that are developing outside DoD at a rapid pace.

DoD will use the schedule and mechanisms provided by the 1995 Base Realignment and Closure Commission process in this restructuring. The DoD goal is to eliminate unnecessary redundancy and low value-added activities. Some savings must be reinvested to improve quality and capabilities. The restructuring, downsizing, outsourcing, and reinvestment should

ensure that the smaller in-house laboratory complex emerges stronger and of higher quality.

Retain a Critical Mass of Internal Expertise. Core competencies in militarily relevant technologies must be maintained in order to support product development, acquisition, evolutionary upgrades of existing material, and crisis response. Some technologies, such as ocean acoustics, thick metal composite materials, and defense against chemical or biological agents, are uniquely and exclusively military. DoD must maintain in-house expertise and facilities in such areas. There are other technologies where increased reliance on industry is desirable and appropriate.

Encourage Innovation. First-rate scientists and engineers with the leeway to investigate high risk, high value opportunities, without fear of failure will innovate. And innovation can move technology forward with great speed. By their very nature, many experiments and explorations change course or run into dead ends due to unforeseen developments and discoveries. Innovative exploration is risky and unpredictable in outcome. The S&T leadership is responsible for encouraging innovation while at the same time allocating resources prudently.

Strengthen Defense S&T Reliance. The military Departments have become increasingly interdependent. This interdependence will increase by design. Defense S&T Reliance is an important vehicle for ensuring that the research efforts of the military Departments and Defense Agencies are fully coordinated and not duplicative. Project Reliance has taken a step forward. It now drafts the Defense Technology Area Plan, allowing all DoD scientists and engineers to work with their colleagues from other organizations, sharing research results and coordinating future research plans, in a commonly held and understood framework. By invitation, the DDR&E has accepted leadership of Defense S&T Reliance.

Monitor and Collaborate International Science Efforts. No longer does the U.S. dominate world science and technology. Those who participate in the DoD S&T program need to monitor the emergence of new scientific ideas and development of mature

technologies internationally. Important reported experiments should be replicated. Where appropriate, we need to increase collaboration with allies and emerging democracies, including countries of the former Soviet Union, to reduce the possibility of technological surprise and ensure we maintain access to leading edge research and key technology development.

VI. CONCLUSION

Tomorrow's readiness depends in part on today's S&T investments. The modernization of our armed forces, and our future ability to prevent, deter or defeat armed threats, are based on the assumption that the United States will remain technologically superior to any possible opponent. DoD's S&T program is envisioned, focused, structured, managed and principled to ensure that superiority within the constraints imposed on us by our budgets.

It is the duty of Defense S&T managers to enable our readiness in the future. This duty is becoming particularly important as the international arms market makes advanced warfighting technologies ever more available. Our nation's potential opponents are growing more diverse, and collectively more capable, as the industrialized nations offer a growing variety of affordable weapons, sensors, platforms and accessories for sale. An adversary equipped with only one or a few commercially-available technologies may have parity with the U.S. in important warfighting systems. Our advantage must come from the integration of many capabilities into a global, dominant forces.

First and foremost, the Defense S&T program is directed to meet the warfighters' needs. To this end, it brings together the warfighters, DoD planners, scientists, and engineers to leverage the opportunities offered by rapid technological changes for defense uses. It focuses S&T on four overarching priorities -- reduced acquisition and life-cycle costs, dual-use technologies, rapid transition and insertion of new technology during all of a system's life-cycle, and maintaining the long-term technology base. To achieve these priorities, DoD guides the S&T efforts managed by the military Departments and Defense Agencies according to five principles -- transition technology, reduce costs, strengthen the industrial base, promote basic research, and assure the continuing quality of our people, facilities, programs, and products.

By this strategy, the DoD S&T program will fulfill Secretary Perry's commitment to build a ready, flexible, and responsive force for a changing security environment -- a force that will continue to maintain and enhance our technological advantage on the battlefield. Well trained and led joint U.S. forces, equipped with advanced capabilities enabled by a broad, integrated S&T program, will be ready to prevent, deter or defeat the future threats to our nation.